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Policy Forums

Dams, politics and drought threat: the march of folly in Brazilian freshwaters ecosystems

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Introduction

Brazil has assumed a position of global leadership in topics related to the environment, conservation, and the sustainable use of the biodiversity (Mittermeier et al., 2010; Scarano et al., 2012; but see Loyola, 2014). However, recent governmental initiatives seem to be moving in a direction opposite to the majority of the compromises and accords reached at the international level, especially with respect to the protection of freshwater aquatic ecosystems. For example, the Federal Government has recently taken several controversial steps, such as the expansion of hydroelectric plants and the promotion of the aquarium trade and more intensive aquaculture through new laws, changes to old laws, "dead letters", and the development of water diversion projects that may substantially increase the introduction and establishment of non-native species.

In this article, we seek to highlight three major initiatives by Brazilian Government because they are directly related to increasing the negative impacts of freshwater non-native species on aquatic ecosystems.

Expansion of hydroelectric plants and their use in aquaculture

Brazil is encouraging the construction of more reservoirs and the introduction of more non-native species into these reservoirs. The Federal Government is both creating and allowing the construction of new hydroelectric dams throughout the country. Brazil already has 1,164 large-scale reservoirs. This number will be increased by more 239 hydroelectric power plants in the next few years, especially in the Amazon region (ANEEL, 2015). Moreover, the previous Ministry of Fishing and Aquaculture (incorporated into the Ministry of Agriculture)

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began a series of policies aimed at expanding the farming of non-native fish species in net cages (i.e. Aquaculture Parks) within Brazilian reservoirs. So far 134 new Aquaculture Parks have been put out to bid and there are many others that have been established without an environmental license.

In Brazil, aquaculture is already the primary activity responsible for the introduction of non-native species. Based on the government actions outlined above, the increase in the number of dams and Aquaculture Parks will provide a window for invasion. The new reservoirs will lead to an alteration of the entire hydrological dynamic of the rivers, transforming extensive river stretches into lentic environments, thereby causing a large reduction in the diversity of native fish and favoring the invasion process. Non-native species originating from net cages and pre-adapted to lentic conditions can easily spread in dammed rivers because of the greater availability of suitable habitats created by the impoundments (Pelicice et al., 2014). The combination of habitat conversion, high propagule pressure due to escapes, life-history traits adapted to impoundments will probably cause biotic homogenization in large scales.

New laws, changes in laws and "dead letters"

In 2012, the Federal Government sanctioned the New Brazilian Forest Act that reduces by more than 80% the area that cannot be deforested within private properties. This will facilitate the implementation of ornamental aquaculture in close proximity to water bodies on hundreds of private properties in Brazil (Magalhães et al., 2011). The development of ornamental aquaculture is strongly encouraged by the current Brazilian government, through actions taken by the previous Ministry of Fishing and Aquaculture. It is regulated by the recent Normative Instruction #16 of 2014, which allows the farming of 2,000 species of ornamental Amazonian fish in other regions of the country (Vitule et al., 2014), and Normative Instruction #21 of 2014 named "Mechanisms for Transit of Aquatic Organisms for Ornamental and Fishkeeping Purposes," which will facilitate the transport of aquarium fish across the country (MPA, 2014). These two new laws will increase the colonization pressure (*sensu* Lockwood et al., 2009) of non-native species within the nation's biomes even more. Together they will lead to a general increase in the number of introduced and established species (Vitule et al., 2014).

In the near future, each of these 2,000 non-native species might have the chance of being released through escape from culture ponds and aquarium dumping by home hobbyists into thousands of streams, rivers, reservoirs and natural lakes, leading to an irreversible process of biotic change (Vitule et al., 2014). It is important to highlight the fact that the invasion of non-native species used in fishkeeping is already occurring in Brazil, and generating biotic changes in beta diversity (Magalhães et al., 2011).

The expansion of aquaculture for the purpose of animal protein production has instigated a series of changes in the laws whose purpose is simply the development of the activity without any concerns about its associated environmental risks. For instance, a law (PL #5989 of 2009) has essentially been approved by the Brazilian Congress that aims to naturalize by decree non-native species with high invasion potential, such as the carps *Aristichthys nobilis*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Hypophthalmichthys molitrix* and tilapias *Oreochromis* spp. (Lima Junior et al., 2012; Pelicice et al., 2014). As described in the body of the text of PL #5989 of 2009, by comparing non-native with native species "*it is aimed to eliminate the normative obstacles which prevent the farming of these species in Brazilian continental waters.*" Among the mentioned obstacles is the entire body of environmental legislation that has been developed over the years with good scientific support.

Another controversial action is the agreement between the previous Ministry of Fishing and Aquaculture and the Ministry of Environment to modify Resolution #413 of 2009 from the National Council of the Environment. The new resolution simplifies the process of applying for and granting the environmental licenses required to conduct cage aquaculture in reservoirs. With the new modification, the licensing of these businesses will be possible in just three months. In addition, it specifies weak inspection and control activities that do not mitigate the negative impacts caused by the establishment of a non-native fish originating from an aquaculture setting (Lima Junior et al., 2014). The new resolution will guarantee opportunities for the development of massive problems related to the non-native species.

Brazilian Environmental Legislation consists of many Normative Instructions (e.g., Federal Normative Instructions #203 of 2008 and #05 of 2008 for freshwater fish species and freshwater shrimp and crayfish, respectively – Brazil, 2008a,b) that restrict the importation of non-native species. The Brazilian Federal Government has allowed the importation of 379 species of non-native ornamental freshwater fish and several crustacean species, while prohibiting the import of 16 non-native fish species and the crayfish *Procambarus clarkii* (Brazil, 2008a,b). Even after the prohibition was put in place, because of inspection failures, eight prohibited fish species, including the predators *Channa* spp., *Clarias batrachus* and the crayfish *P. clarkii*, are still present in the Brazilian aquarium trade and under strong risk of being released into natural environments throughout Brazil by home hobbyists because of their large size and aggressive behavior (Magalhães, 2015).

Water diversion and man-made channel projects

Due to the current water crisis, the Brazilian government has undertaken several controversial measures such as flow diversion projects linking isolated river basins in São Paulo state (Vitule et al., 2015). This is not the only diversion project; other large-scale projects are currently being built or are in the planning stages. For instance, the São Francisco River Integration Project is being developed with the purpose of transporting water from the São Francisco River Basin to different coastal basins in Northeastern Brazil (Ministério da Integração Nacional, 2015); plans should be finalized in 2016. And, in anticipation of increased water demands in the Northeast and decreased flow in the São Francisco River basin, there are initiatives studying the potential diversion of water from the Tocantins River (Amazon River Basin) to the São Francisco River. There is already a law (PL #6569 of 2013) before the

Brazilian Congress authorizing this proposal (Pelicice et al., 2014). These water diversions will lead to the massive displacement and introduction of organisms, resulting in biotic homogenization in the Southeastern, Northeastern and North regions of Brazil.

Another worrying initiative is the Hidrovia Channelization Project, proposed to convert 3400 km of the Paraguay and Paraná River systems into a shipping canal that would stretch from the city of Cáceres, Mato Grosso state in Center-West Brazil, to the Atlantic Ocean near Buenos Aires in Argentina. This project is highly controversial because of the potential adverse environmental consequences, such as the introduction and spread of the golden mussel *Limnoperna fortunei*, an invader already introduced in the Pantanal region (Boltovskoy et al., 2006).

Conclusions

While some countries and regions are taking steps toward restoring aquatic ecosystems through the removal of reservoirs and the development of better controls over the introduction and establishment of non-native species (Leadley et al., 2014), Brazil is adopting measures that move in the opposite direction. This will undoubtedly lead to the impoverishment and loss of our native biological heritage and all of the ecosystem services it provides. Therefore, we must fight against the expansion of dams and reservoirs and their use for the aquaculture of non-native species, against new detrimental laws (Law #16 of 2014), changes in existing laws (Law #5989 of 2009), and "dead letters" (Laws #203 of 2008 and #05 of 2008). All these changes will put at risk our overall objective of maintaining the unique Brazilian native aquatic biodiversity and its concomitant ecosystem services. Brazil has created the illusion that somehow its aquatic biodiversity is impregnable or that it is somehow peripheral to our contemporary world. The truth is we need it more than ever in a country of more than 200 million people. Otherwise, Brazil will continue "Living in Disharmony with Nature" due to an increasing in rate of new introductions.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

ANEEL, 2015. Banco de Informações de Geração, Available from: http://www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.cfm (accessed 20.03.15).

Boltovskoy, D., et al., 2006. Dispersion and impact of invasive freshwater bivalves: *Limnoperna fortunei* in the Río de la Plata watershed and beyond. Biol. Invasions 8, 947–963.

Brasil, 2008a. Ministério do Meio Ambiente. Instrução Normativa N° 203, de 22 de outubro de 2008. Dispõe sobre normas, critérios e padrões para a exportação com finalidade ornamental e de aquariofilia de peixes nativos ou exóticos de águas continentais. DOU 207., pp. 87–91.

Brasil, 2008b. Ministério do Meio Ambiente. Portaria N° 5, de 28 de janeiro de 2008. Não autorizar, em todo território nacional, a introdução, reintrodução, importação, comercialização, cultivo e transporte de indivíduos vivos da espécie *Procambarus clarkii*. DOU 57., pp. 57–88.

Leadley, P.W., et al., 2014. Progress Towards the Aichi Biodiversity Targets: An Assessment of Biodiversity Trends, Policy Scenarios and Key Actions. Secretariat of the Convention on Biological Diversity, Montreal.

Lima Junior, D.P., et al., 2012. Aquicultura, políticas e meio ambiente no Brasil: novas propostas e velhos equívocos. Nat. Conserv. 10, 88–91.

Lima Junior, D.P., et al., 2014. Modificação das diretrizes do CONAMA nº 413/2009 sobre licenciamento ambiental da aquicultura: retirando os "obstáculos normativos" para a criação de espécies não nativas em águas brasileiras. Bol. ABLimno 40, 3–11.

Lockwood, J.L., Cassey, P., Blackburn, T.M., 2009. The more you introduce the more you get: the role of colonization pressure and propagule pressure in invasion ecology. Divers. Distrib. 15, 904–910.

Loyola, R., 2014. Brazil cannot risk its environmental leadership. Divers. Distrib. 20, 1365–1367.

Magalhães, A.L.B., 2015. Presence of prohibited fishes in the Brazilian aquarium trade: effectiveness of laws, management options and future prospects. J. Appl. Ichthyol. 31, 170–172.

Magalhães, A.L., Casatti, L., Vitule, J.R.S., 2011. Changes in the Brazilian Forest Law will promote non-native species of freshwater fish. Nat. Conserv. 9, 221–224.

Ministério da Integração Nacional, 2015. Projeto São Francisco – Eixos do projeto, Available from: http://www.integracao.gov.br/eixos-do-projeto (accessed 20.03.15).

MAP – Ministério da Pesca e Aquicultura, 2014. MPA simplifica transporte de peixes ornamentais, Available from: http://www.mpa.gov.br/index.php/ultimas-noticias/444-mpa-simplifica-transporte-de-peixes-ornamentais (accessed 04.05.15).

Mittermeier, R., et al., 2010. O protagonismo do Brasil no histórico acordo global de proteção à biodiversidade. Nat. Conserv. 8, 197–200.

Pelicice, F.M., et al., 2014. A serious new threat to brazilian freshwater ecosystems: the naturalization of nonnative fish by decree. Conserv. Lett. 7, 55–60.

Scarano, F., Guimarães, A., da Silva, J.M., 2012. Lead by example. Nature 486, 25–26.

Vitule, J.R.S., et al., 2015. Brazil's drought: protect biodiversity. Science 347, 1427–1428.

Vitule, J.R.S., Sampaio, F.D.F., Magalhães, A.L.B., 2014. Monitor Brazil's fish sampling closely. Nature 513, 315.